REMARKS/ARGUMENTS

Claims 1-2 are pending in the application. Claims 1-2 are amended and new claims 3-19 are added in the present amendment.

Claims 1 and 2 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,552,605 to Arata. Applicant respectfully traverses this rejection.

The Arata reference discloses a method to compensate for patient motion in diagnostic imaging. Some patient motion is common given the long scan times for some single photon emission computed tomography (SPECT) imaging procedures. The Arata reference provides a method an apparatus for correcting image distortions caused by motion occurring during a SPECT imaging procedure.

During the procedure disclosed in the Arata reference, a radiation detector is rotated around a patient at incremental projection angles. The radiation detector produces electrical data indicative of received radiation from an examination region. At each projection angle, the electrical data forms a two-dimensional projection view of a region of interest within the patient. A reconstruction processor reconstructs the multiple projection views into a three dimensional reconstructed image representation of the region of interest. A reprojection circuit reprojects the reconstructed image representation at each of the original projection angles to produce a set of reprojection views. A view comparator compares each projection view within a region of interest with a corresponding reprojection view produced at the same projection angle. An offset between these two views is determined and the projection view is translated by this offset to produce a

corrected projection view. The corrected projection views are reconstructed into a corrected three-dimensional reconstructed image representation. In other words, the invention disclosed in the Arata reference provides a method and apparatus for motion correction based on reprojection data.

There are many common prior-art processes like image reconstruction, sinogram reprojection, and image registration that are well known and used in various imaging processes. Image reconstruction is defined as converting a raw sinogram data set into an image. Sinogram reprojection is defined as converting an image into a sinogram data set. Image reconstruction and sinogram reprojection are simple inverses of each other. The process known as iterative reconstruction and reprojection (IRR) has existed for many years (e.g. G. T. Herman and A. Lent, "Iterative reconstruction algorithms," Comput. Biol. Med., vol. 6, pp. 273-294, 1976). One option for IRR is as a means to reconstruct images given unflawed data.

The data set of projection views acquired in the process disclosed in the Arata reference is complete, but potentially inconsistent due to patient motion. The Arata method operates to reconstruct an initial image from raw sinogram data, then reproject new sinogram data from this first reconstructed image, and finally to shift the raw sinogram data to be consistent with the reprojected sinogram data. This shifted raw sinogram data is reconstructed into an updated image.

The present invention provides a method of reconstructing incomplete data sets, which otherwise cause distinctive artifacts. The Arata reference only discloses the application of deblurring patient motion. These two types of degradations have different sources, affect the

collected data volumes in different ways, have different effects on the images, and consequently, require different solutions. The Arata reference does not discuss other applications besides deblurring patient motion, and certainly makes no reference to compensating for limited data availability. On the contrary, the Arata reference implicitly assumes complete data sets in that it never even mentions the possibility of missing necessary scan data, and the method would not mitigate the degradation caused by limited data availability. Both the initial and final images would be degraded.

The present invention provides the incorporation of *a priori* data, or imperfect *a priori* data. This is an important distinction from Arata. The Arata reference discloses modifying the original sinogram based upon comparisons with a reconstructed and reprojected version of itself (self-consistency), whereas incorporating additional data is fundamental to the present invention. The present invention "augments" the image data, which is a way to create a new sinogram with the missing regions filled-in by intelligently estimating them from a separate data set; whereas the Arata reference "shifts" the image data, which is a way to create an adjusted sinogram by keeping the same complete data, but rearranging it to "undo" patient motion. Finally, the registration process of the present invention is different from the registration process of the Arata reference. In the present invention, registration is typically done in image space. This is possible because there are two independent images (re: the new image we are working on, and the *a priori* image.) The registration of the resent invention may also be done in sinogram space. The Arata reference cannot register in image space because there is only one image. It is not until the completion of the iteration (reprojecting, registering in sinogram space, and reconstructing again) that a second

image is created. And the second image is not a second independent image, but an improved version of the first image.

The Arata reference does not disclose the possibility of having limited data; or for compensating for limited data. The Arata reference does not disclose using a priori data sets to improve the image quality. Arata makes no provision for large patients, or other situations in which the data would be incomplete, even though these situations would impact his image quality, and his correction technique would not compensate for such degradations.

In response to the Examiner's allegations in claim 1 that the Arata reference teaches "obtaining a first sinogram data set" and "reconstructing the first sinogram data set into a first image." These are standard prior art features of standard reconstruction and IRR techniques.

The claim 1 element of "aligning the first image to second image so that optimal registration between the first and second image is obtained" is not taught or suggested by Arata. Arata's process only uses a single image at a time (i.e. for each iteration). There is no second input image, and there is no disclosure of working with two images at a time. Instead, each iteration of the process begins with a single sinogram, creating a single image, creating an updated sinogram from that image, and then creating an updated image. If performed iteratively, this process may then use this "second" image, but even then it is only using the second image, and is not aligning images, or otherwise using two images together. Thus, claim 1 is different in that there are two separate images as inputs during each iteration, one being the current working image and the other being an *a priori* image. As such, the Arata reference never performs registration between two images.

The claim 1 element of "reprojecting the aligned image into a reprojected sinogram data set" is also not taught or suggested by Arata. Arata does not disclose registration or alignment of the reconstructed images. Instead, Arata reconstructs a single image and reprojects it immediately. There is no image registration or alignment, since there is no other image to align or register to.

The claim 1 element of "extracting data from the reprojected sinogram data set that is not available in the first sinogram data set" is similar to the registration taught in Arata. Arata does registration of the sinogram data after reprojection. The original sinogram data is shifted to align with the reprojected sinogram data. In principle, if there was no patient motion, the reconstructed and reprojected sinogram would exactly match the original sinogram (they are inverses of each other), so there would be no correction. But in the presence of patient motion, portions of the sinogram might be shifted relative to one another, so they are "undoing" those patient motions. However, Arata does not "extract data from the reprojected sinogram data set that is not available in the first sinogram data set" because i) the Arata method is not used to compensate for data that is not available, the Arata method is to compensate for patient motion in cases where all of the data is available, but not necessarily consistent with itself, ii) "extracting" means taking data from a second independent source (the realigned, reprojected second-input image), for use in the original data set. Arata does not disclose a second-input image, and consequently does not realign it, reproject it, or extract data from it.

The claim 1 element of "augmenting the first sinogram data set with the extracted data from the reprojected sinogram to obtain an augmented sinogram data set" is also not taught or

suggested in the Arata reference. The augmentation process of the present invention takes data from an original sinogram, and replaces portions or complete missing portions of the original sinogram with data from a second image that has been aligned, reprojected, and had relevant sections extracted. The Arata reference does not disclose a second input data set, so there is no process of "augmenting" an original sinogram with a separate, independent sinogram. Instead, the Arata "adjustment" is to take data from the original sinogram, the only original sinogram, and shift the data in accordance with patient motion. Not only is the adjusted sinogram comprised entirely of data that is in the original sinogram, but the information used to detect the shift derives solely from processing done on only that original sinogram. So the Arata reference does not combine original data with data from a separate source, or even use information from a separate source as a guide for how to do the data manipulation.

The claim 1 element of "reconstructing the augmented data set into a third image" is also not taught or suggested in the Arata reference. Since the present invention includes two images as inputs, a third image is reconstructed from the augmented sinogram. In contrast, the Arata reference begins with a single data set, creates a single image, but does not "augment" the sinogram with independently processed data. The data is reconstructed into a second image, not a third image.

With regard to claim 2, the Arata reference does not disclose compensating for missing or incomplete data or the degradation that results. The algorithm disclosed in Arata does not correct or compensate for missing data or limited data, and limited data images would suffer from

artifacts whether or not Arata's method was applied. The Arata reference does not discuss, nor claim, nor enable reconstruction of incomplete data.

New claims 3-19 are included to further define the invention and recite elements not in the original set of claims. None of the cited prior art references, whether taken singly or in combination with another, teach or suggest applicant's claimed invention. Therefore, Applicant believes that claims 1-19 contain patentable subject matter and are in condition for allowance.

In view of the amendments and remarks presented above, the Applicant believes that the application is now in condition for allowance, and respectfully requests reconsideration of the application, withdrawal of the rejections and allowance of the claims. No new matter has been added to the application. The Applicant respectfully requests that the Examiner telephone the undersigned in the event a telephone conference would be helpful in advancing prosecution of the application.

Respectfully submitted,

GODFREY & KAHN, S.C.

Dated: 01/07/2004

By: William K. Baxter
William K. Baxter
Reg. No. 41,606

Attorneys of Record for Applicant
GODFREY & KAHN, S.C.
780 North Water Street
Milwaukee, WI 53202-3590
Telephone: 414-273-3500
Facsimile: 414-273-5198
Email: wbaxter@gklaw.com

MW755631_1.DOC